AUTOPLASTIC TRANSPLANTATION OF BONE.

BY HENRY H. JANEWAY, M.D.,

OF NEW YORK.

THE conditions which make it desirable to replace bony defects are by no means of rare occurrence. Chief among them are deficiencies of the cranial bones, of the inferior maxilla, and of the long bones of the extremities, occasioned by osteomyelitis, by injuries, or by the removal of tumors. Finally, in a class by themselves, are the pseudarthroses.

Notwithstanding the frequent occurrence of all these conditions, the available methods of making good such defects have never been popular.

If, however, there does exist a satisfactory means of replacing these losses in the continuity of bone, its infrequent utilization is to be regretted, for consequential upon them must be mentioned not only a prolonged course of healing but frequently, also, serious deformities and loss of function, a loss often great enough to demand amputation.

In their views upon this subject surgeons have been influenced by the undesirability of implanting in a defect between or within bones any foreign substance, and their belief that all homoplastic grafts must be included in this category.

There is a manifest failure to appreciate the actual fate of a periosteal bone graft. The numerous successful osteoplastic operations upon the cranium, however, should encourage autoplastic transplantation of bone and periosteum in other locations. On numerous occasions bony buttons or chips have been replaced into cranial defects and successfully healed in. (Kuester, Von Jaksch, Watson Pike, Gerstein, William Jones, Von Braman, Weir, Moller, Eastman, Bunge, Macewen.)

Probably more to the susceptibility of bone and periosteum to successful autoplastic transplantation than to the preservation of the vascular supply must be attributed the success of

the Haeker-Durante sliding flap method (Durante, Haeker, Sultan, Borchard, Sohr); and it is not impossible that the same statement is also true of even the Müller-König method, for the retention of the vascular supply in either of these methods is small (Müller, König, Shönborn, Mikulicz, Braun, Slajmer, Gussenbauer, Riegner, Korte, Brenanto, Bernay, Von Eiselberg, Karewski, Milko).

It has long been appreciated that foreign bodies of almost any description can permanently be healed within wounds. A. Fraenkel first suggested the use of celluloid plates for the closure of cranial defects, and since that time the procedure has been frequently resorted to with a greater or lesser degree of success (Fraenkel, Billroth, Von Fillenbaum, Weinlechner, Hinterstoisser, Berger, Von Frey, Link, Porges, Fritsch, Pringle, Blecher).

Gluck, Bircher and König have described the successful replacement of losses of bone by pieces of ivory. König still enthusiastically advocates the procedure to correct the deformity produced by resection of portions of the inferior maxilla. Kopfstein replaced a resected upper portion of a humerus with a piece of ivory driven into the remaining part of the humerus below and fitted by a rounding of its upper extremity into the glenoid cavity (Bircher, Gluck, Kopfstein, König).

Lambotte and Elsberg have reported the implantation of aluminium plates within cranial defects and Gerster has utilized gold for the same purpose.

Perhaps the most remarkable instance of the implantation of foreign bodies is recorded by Giordano who permanently replaced a gap of 23 cm. in a tibia with a piece of metal capped on both ends with ivory disks.

Somewhat more extended use has been made of heteroplastic transplantation of bone from animals. Many successful cases have been reported. The literature dates back to 1682 when Jobi Meekren replaced a defect in the cranium of a soldier with a piece of a dog's skull. The implanted fragment healed in perfectly. It is interesting to note that antivivisection cruelty to human beings was in those days more

successfully active, and Jobi Meekren was required to remove the implanted fragment under the ban of excommunication by the church which refused to recognize such "unchristian" methods of treatment. "Chirurgicum ossis cranii fragmentum anferre jussit, sicque, curatione alia adhibita excommunicationis vim effugit. Jobi a Meekrenobservat medico-chirurg." Ex Belgico in lat. transl. of A. Blasio, Amsterdami, 1682, pp. 6–7.

Beginning in the year 1810, the following have reported successful heteroplastic grafting of bone: Merrem, Merrem and Von Walther, Flourens, J. Wolf, Ollier, Goujon, Marshall, Adamkiewicz, White, Sherman, MacGill, Sherwood, Ochotin, Chalot, Forgue, Le Dentu, Ricard, Perier, McGraw, Buchanan, Mosse, Kronacher, Petit, Patzauer, Smolony, Krausch, and Tomita.

Pathologically, of a similar nature is the filling in of losses of bone by decalcified bony chips, first proposed by Senn and subsequently reported upon by Deaver, Le Dentu, Middeldorpf, Mackie, Miller, Murray, Spediacci, Curtis, and Wagenknecht.

For the sake of completeness, reference will be made to the heteroplastic transplantations with preservation of vascular connections by Phelps and Morton, and also the iodoform plug of Mosetig Moorhof. The latter method has received favorable notice by a number of foreign writers and in this country by Wetherill and the Mayo brothers.

None of these methods can be said to be entirely satisfactory. Healing often occurs only after considerable length of time. The formation of fistulæ are not infrequent, and many times a number of the bony fragments have been discharged. In general, they offer a contrast to those cases in which defects in the continuity of bones have been replaced by the implantation of a fresh piece of bone together with its adherent periosteum which is taken from the same individual or another human being.

Recorded instances of this latter method are few in number. They nevertheless indicate that the procedure is one of real

value, and, if subsequent experience proves as favorable, the desirability of more frequently resorting to it is at once apparent and justifies the recording of the author's case.

CASE.—Patient, L. K., an American woman, at present forty-two years of age.

Previous Personal History.—When a child, had malaria and scarlatina followed by a mild nephritis, from which she apparently made a complete recovery. At eighteen years of age she married. During the next three years she had two miscarriages and one child born at term and dying of marasmus when it was five months old. This child had a bullous eruption upon the soles of its feet, some general eruption upon its body, and a condition of the eyes resembling parenchymatous keratitis. Subsequently, the patient had another child who is to-day healthy.

Present Trouble.—Twelve years ago the patient had a severe wrench to her arm, described as a pull accompanied with a sudden twist. She felt considerable pain after this, and three months later she noticed a lump in her arm. This gradually increased in size until seven years ago when she received without benefit a course of mixed treatment.

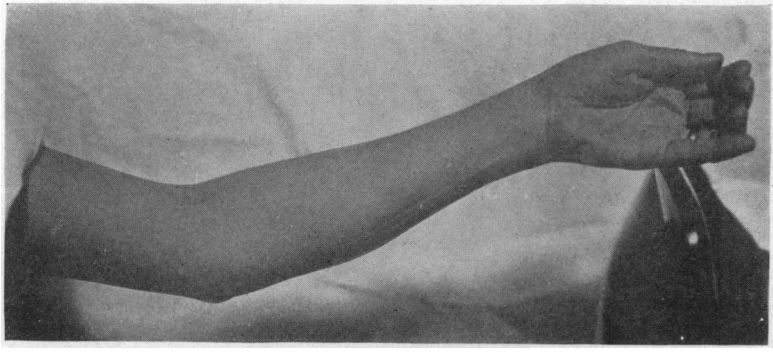
The growth at that time was hard, nodular and immovably bound down by the muscles of the forearm, in which it caused a fusiform enlargement five inches in length. The whole tumor was exposed and found to be attached to the anterior surface of the ulna by a flattened pedicle. It was removed and the ulna at the point of attachment of the growth curretted. In one year's time a recurrence of the growth was noticed. The recurrent mass measured about two inches in length and was attached to the ulna at the juncture of its lower third and upper two-thirds. This mass was extirpated under general anæsthesia and one year and three months later another small nodule was excised under cocaine. Again, within a few months, a fourth recurrence of the growth was noticed. The patient, however, neglected treatment until November 26, 1908, one year and three months after the preceding operation. She was then placed under the author's care in the Francis E. Parker Memorial Hospital, New Brunswick, N. J.

Fig. 1 represents the size of the growth at that time when the final operation was undertaken. Through an incision along the

FIG. 1.

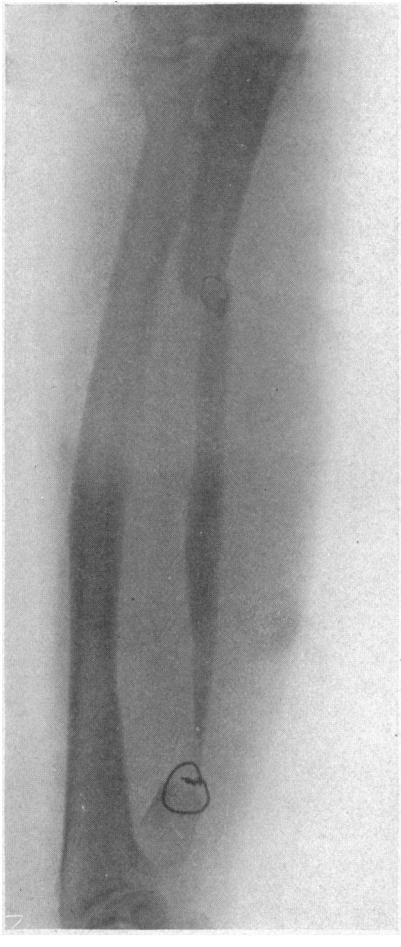
Condition of forearm immediately previous to operation.

FIG. 2.



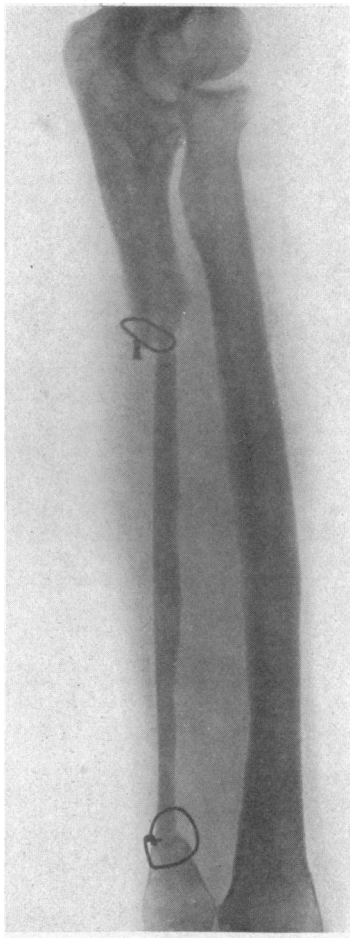
Condition after healing of operation wound.

FIG. 3.



Condition of bones one month after operation.

FIG. 4.



Condition of bones four months after operation.

FIG. 5.

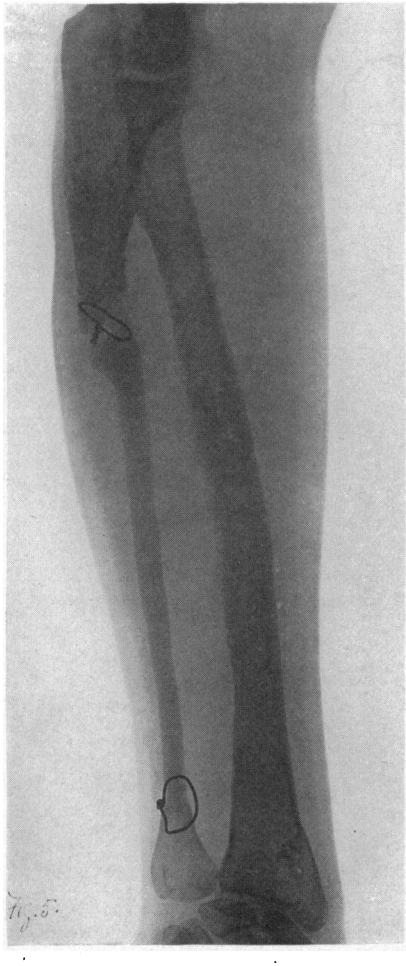
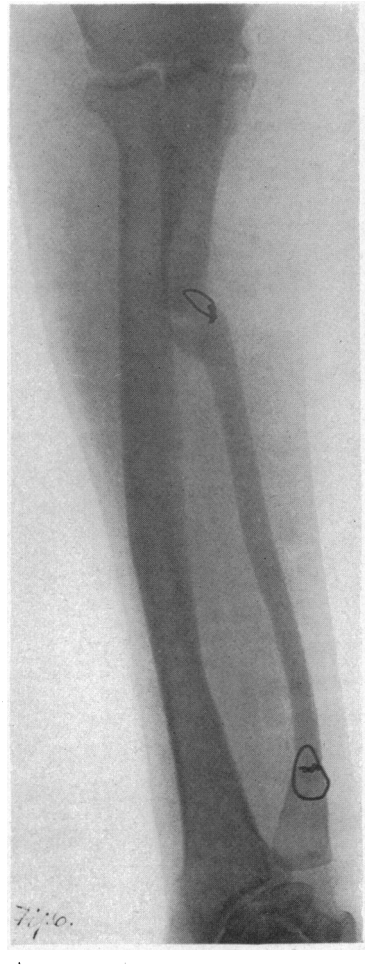


FIG. 6.



Condition of bones fourteen months after operation.

posterior border of the ulna and dividing the joined aponeurosis of the extensor and flexor carpi-ulnaris, the tumor was removed by resecting a portion of the ulna five and one-half inches long, which ran through the centre of the growth.

A fragment of bone of the same length and three-eighths inch wide and one-eighth inch thick was now chiselled off from the crest of the tibia together with its adherent periosteum.

This was then placed between the two extremities of the ulna remaining and fastened in place with silver wire. The periosteum of the implanted fragment was also sutured to the periosteum of the remaining portions of the ulna. The wound was now closed with the exception of a small drain at each end.

After the first twenty-four hours the drains were removed and a plaster splint applied. Thereafter, the wound was dressed on the fourth, seventh, and tenth days, at the end of which time it was healed throughout. At no time was there any elevation of temperature. In two months time the patient could freely use her arm for washing clothes at a tub. Fig. 2 illustrates the healed condition of the arm. Microscopical examination showed that the growth was a chondrosarcoma.

The accompanying radiographs were taken at intervals of one month (Fig. 3), four months (Fig. 4), and fourteen months (Figs. 5 and 6) after the operation. They demonstrate the increase in thickness of the implanted fragment and the formation of callus at its upper end by the implanted periosteum, and at its lower end the direct union of the implanted piece with the ulna.

If we inquire into the nature of the histological processes which have taken place, we must assume as a result of the conclusions of research work upon implanted bone and periosteum that the implanted bone itself had died, but that the periosteum and marrow lived and replaced the old bone with new.

As long ago as 1867 Ollier recognized the important rôle played by the periosteum and marrow. He states: "Quand on a transplanté un os entier, ou une portion d'os garnie de son périoste et de sa moelle, il arrive quelquefois que le périoste seul se greffe; le cylindre osseux se nécrose, se détache, est eliminé, et l'on trouve cependant dans le lieu de la transplantation la gaîne périostique ossifiée. Par sa surface externe elle

a adhére aux tissus voisins, et c'est ensuite séparée de l'os ancien nécrosé."

And referring to an experiment in which he successfully transposed the radii of a rabbit he states: "Cette observation nous paraît demonstrer à elle seule la plupart des propositions que nous émises dans ce chapitre la réalité de la greffe osseuse et le role du perioste et l'utilité de cette membrane, même dans les cas ou le tissu osseux lui même ne se greffe pas."

Subsequent work has, in a large measure, verified and at the same time amplified Ollier's work.

There is a general agreement between the conclusions of Radzimowski, Bonome, Saltykow, Fischoeder, Marchand, Sultan, Tomita, Grohe, Morpurgo, Läwen, Barth (latest publication) and Auxhausen. An examination of the only dissenting works by David, Adamkiewicz, and Laurent, who alone maintain the viability of the implanted bone, will not support their opposing claims.

All others have recognized the death of the implanted bone, its revascularization and penetration by granulation tissue, and through this means the formation of new Haversonian canals, the lining of the new vessels with osteoblasts, and by their agency the absorption of the old bone and the deposition of new bone in concentric layers around the new formed vessels. Finally, that these changes are solely dependent upon the living and regenerative power of the transplanted periosteum and marrow.

The remarkable viability of the transplanted periosteum has been demonstrated by Grohe and Morpurgo, the former showing that it is capable of preservation for one hundred hours and yet able to be implanted and exert its osteogenetic powers. The latter has shown that the periosteum of a corpse kept at 15° can produce new bone when implanted after one hundred and sixty-eight hours. Läwen has recommended the use of periosteum in the repair of ventral hernia.

The histological demonstration of the viability and regenerative power of implanted periosteum at once places homoplastic transplantations of bone upon an entirely different

footing from any other method of making good bony defects. When the cases of the former method of transplantation are compared with those in which there has been transplanted bone from animals or decalcified dead human bone (Krausch), or even live human bony chips (Macewen), a difference seems to exist in the course of healing of the wounds, in the character of the end result, and in the rapidity with which the latter is obtained. In addition to the author's case, other cases of rather extensive homoplastic transplantation of bone have been reported by Poncet, Kummel, Bardenheuer, Von Bergmann, Klapp, Curtillet, Tomita, Perthes, Lexer, Frankenstein and Rovsing. Similar small transplantations have been made by Timann, Tietz, Müller, Von Mangoldt, Dryden, and Auxhausen.

In one of Bardenheuer's cases half of the ulna was used to replace a radius.

In Von Bergmann's case a portion of the tibia 11 cm. long was resected for sarcoma and replaced by a piece taken from the fibula.

Klapp replaced the whole of the diaphysis of the humerus (also resected for sarcoma) with a piece of bone and periosteum removed from the crest of the tibia.

Tomita has reported five cases of bone transplantations, two of these were heteroplastic, one was for a pseudarthrosis, and two were fairly extensive autoplastic implants. In one of the latter, a portion of the tibia 8 cm. long was implanted into a defect 6 cm. long lower down in the same bone.

In the other, a piece of the left tibia 7 cm. long was implanted into a defect of 5 cm. occurring in the tibial diaphysis.

Frankenstein resected 25 cm. of a femur for sarcoma and implanted within the defect a resected fibula. The implanted bone healed in well and formed firm union below, but a pseudarthrosis resulted at the upper end of the implant. In seven months' time the patient died of metastases. Sections of the removed transplanted bone showed active proliferation of its periosteum and marrow and a replacement of the old bone by a network of newly deposited osseous tissue.

Finally, and of considerable importance, is the transplantation of joints by Lexer. In his first publication he reports four functionally successful cases in which portions of bones with adjacent parts of joints have been replaced by bone and cartilage covered with their periosteum or perichondrium.

In his second publication he adds the report of a total transplantation of a knee-joint in a girl eighteen years of age. In eighteen months' time the patient could walk with only a slight limp and rocking of the knee-joint.

Läwen has reported the replacement of the upper half of a humerus resected for sarcoma with a portion of bone and periosteum removed from a tibia. In Rovsing's case two-thirds of the humerus was replaced by the patient's own fibula.

These cases are not numerous but they are sufficient to illustrate the possibilities of homoplastic transplantation of bone and the superiority of the method compared to heteroplastic transplantation or even, as in the case recently reported by Macewen, to the implantation of fresh human bone chips.

Both Tillmann and Tomita, but particularly the latter, who has tried several methods on the human, have commented on this superiority. Tomita states: " Aus den oben aus einander gesetzten Gründen spechen unsere Fälle vielleicht dafür, das die methode mit homoplastischer oder autoplastischer Füllung die bessere ist."

Certainly in the author's case the healing of a simple green-stick fracture could not have been more simple; and the ultimate cosmetic and functional result is all that could be desired.

In conclusion the case illustrates the peculiar adaptability of the tibia (its accessibility and its great strength and thickness) to the function of furnishing a suitable bony graft. The radiographs (Figs. 3 to 6) demonstrate that such an autoplastic graft firmly unites to the fragments between which it is placed and eventually becomes transformed into a thicker piece of living bone, its thickness being determined by the demands for strength required in its new situation. Finally, in the case cited the smooth and rapid healing is an indication that the autoplastic method of remedying bony defects is the pro-

cedure of choice and is deserving of wider application than it at present is receiving.

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